Appendix D5
Ballast Water System Operations and Design Features

WorleyParsons bhpbilliton

Project Title:	Subject:
CABRILLO PORT LNG TERMINAL	**Ballast Water System Operations and Design Features**

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1 OBJECTIVE

This report has been prepared to provide a response to the following questions:
1.1 (Reference EDC, doc #884:

"Please describe the process by which the LNG carriers would take on ballast and how the FSRU would take on and discharge ballast water. At a minimum, please detail how often this would occur, the volumes, and the range of intake flow rates/velocities for the FSRU and LNG carriers, and the range of FSRU discharge flow rates/velocities"

1.2 (Reference Heal the Bay, doc #892; CCC, doc #859):

"Provide a discussion of the rationale (and biological basis) for the selection of screen size, number of screens, design, and location of uptake valve (at 43 ft below the water) for both the LNG carrier and FSRU. Were other depths considered for the uptake pump valve? Is it feasible to install a subsurface intake for the FSRU (one that extends into the sandy substrate on the ocean floor to avoid impingement and entrainment)?"

2 OVERVIEW

In order to address the issues raised by these questions it is necessary to provide a detailed explanation of the terms used in describing the ballast system and associated screening systems, typically used on both the FSRU and the LNG carriers used to deliver LNG to the FSRU.

There are numerous variables which must be fixed in order to provide firm details on the ballast system characteristics. Several of these have been determined and previously submitted as part of the DEIS/DEIR documentation for the Cabrillo Port receiving terminal. Other variables and relationships required are detailed in the General Operations Assumptions.

The Ballasting Process is described in detail and the resultant information on frequencies of ballasting, volumes, intake flow rates and velocities provided in tabular form. Information is provided on the basis for ballast system screen location and sizing, together with commentary on the feasibility of an extended depth of uptake location.
Figures 1 & 2 together with the diagram in Appendix A provide further information on the proposed arrangements of the ballast system for the FSRU.

3 TERMINOLOGY

Ballast – Any inert substance or material used specifically for the purpose of providing weight at strategic locations within a ship to maintain the trim, stability, hull girder stresses, and draft of the vessel within designated safe operating parameters. For many types of vessels, such as LNG carriers, ballast is loaded aboard the ship to compensate for the weight and location aboard of the cargo being discharged from the ship; conversely, ballast is discharged from the vessel to compensate for the weight and location aboard of the cargo being loaded onto the ship. Water is used as the ballast material of choice for LNG carriers.

BW (Ballast Water) – Water used as ballast in purpose-built water tanks integral to the structure of the LNG Carrier or Floating Storage and Regasification Unit. These ballast water tanks are segregated from other tanks onboard, such as the LNG cargo tanks, and are used only for water ballast and for no other purpose.

Draft – The vertical distance between the waterline and the lowest external point below the waterline on a vessel's hull.

External Grill (or grate) – a coarse filter covering the sea chest opening to the sea to prevent potentially damaging material (large debris, marine life, and seaweed) being sucked into the sea chest.

Freeboard – The vertical distance between the waterline of a vessel and its lowest open deck or "weather deck". In the case of the FSRU and LNGCs, it will be the vertical distance between the waterline and the main deck.

FSRU (Floating Storage & Regasification Unit) – the LNG receiving terminal for the Cabrillo Port LNG Deepwater Port.

LNG – Liquefied Natural Gas.

LNGC (Liquefied Natural Gas Carrier) – also known interchangeably as an LNG tanker, LNG ship, or LNG vessel.

NG- Natural Gas

Sea Chest- A opening in the vessel's hull designed to minimise hull skin friction, generate laminar water flow over the hull and reduce suction velocities and disturbances at the point of intake to the ballast system (or other systems requiring sea water e.g. fire water). Typically the sea chest open area will be at least twice the total flow area of the inlet pipe or valves connecting to the ballast system.

Screen/ Strainer- a fine filter provided between the sea chest and the suction pipe to prevent suction of potentially damaging material into a vessel's pipe work and pump intake.

SW (Sea Water) - Saltwater from the open ocean.

Uptake Valve- for the purposes of this response the uptake valve will be interpreted as meaning the ballast system inlet isolation valve located on the inboard side of each sea chest.

4 GENERAL OPERATIONS ASSUMPTIONS

The following assumptions are based upon universally employed basic tenets associated with all LNGC cargo discharge operations alongside a receiving LNG terminal, and specific technical information related to ballast and cargo systems and operations previously submitted as part of the DEIS/DEIR documentation concerning the Cabrillo Port receiving terminal. The Cabrillo Port LNG receiving terminal is a FSRU having LNG cargo system and ballast system characteristics very similar to that of a LNGC.

4.1 Ballast-Related Physical Property and LNG Cargo Assumptions:

- Density of Fresh Water (FW) = 1000 kg per cubic meter (M3)
- Density of Salt Water (Seawater or SW) = 1027 kg per cubic meter (M3)
- Density of LNG = ~ 450 kg per cubic meter (M3)
- Weight of 1M3 LNG / Weight of 1M3 of SW = 450 / 1027 = 0.4382

4.2 Ballast and LNG Cargo Operations Assumptions:

4.2.1 210,000M3 LNGC Cargo Discharge

- Maximum LNG discharge rate determined by 3 off 16in loadings arms, each rated at 5000M3/hr is 15,000M3/hr.
- Effective LNG cargo capacity of 210,000M3 LNGC is ~195,000M3 due to storage of LNG for fuel and maintenance of cold tanks
- Equivalent 195,000 M3 LNG volume's weight of SW Ballast volume required to be pumped into the LNGC Ballast Tanks per load = 0.4382 X 195,000M3 = 85449M3 SW
- LNG Volume received aboard FSRU per load= 195,000M3 LNG
- Equivalent LNG volume's weight of SW Ballast volume required to be removed from FSRU's Ballast Tanks = 0.4382 X 195,000M3 = 85449M3 SW per load
- Based on discharging 195,000M3 of LNG @ 15,000M3/hr rate, LNGC discharge period is 13 hours. The actual discharge period will extend beyond this time due to the requirement to "ramp-up" the pumping rate at commencement and to slow down the pumping rate near the completion to facilitate safe "topping-up" of the LNG tanks.
- Rate of FSRU SW Ballast to be discharged due to LNG loaded from LNGC = 85449M3 ÷ 13 = 6573 M3/hr (**A**). Whilst the actual discharge rate will vary due to the LNG pumping factors noted above, plus operational practicalities the figure quoted provides a realistic estimation of the maximum flow rate to use in velocity determinations.
- LNG Volume removed from FSRU because of LNG that is Regasified to NG and sent to shore via pipeline from FSRU @ 800MMscfd rate = ~ 35,000M3 LNG per day
- Equivalent removed LNG volume's weight of SW Ballast volume required to be pumped into FSRU's Ballast Tanks due to Regasification (only) = 0.4382 X 35,000M3 = 15360M3 SW per day or 640 M3/hr(**B**). It should be noted that this is an average rate. Due to operational

practicalities it is likely this ballast intake rate will be higher for two or three periods during each day, and be zero at other times.

- Volume of Ballast SW required to be discharged from FSRU during loading of a 210,000M3 LNGC is **A** – **B** = 5933 M3 /hr. As noted above **B** is an average rate, however, it is a reasonable basis for determining the maximum FSRU discharge rate.

- At all times except during LNGC loading into the FSRU, the FSRU SW ballast is being added to the FSRU at an average rate **B**, 640M3/hr. Whilst this is an average rate, based on the factors noted above, it is a realistic figure to provide a velocity determination at the low end of the flow range.

4.2.2 138,000M3 LNGC Cargo Discharge

- Maximum LNG discharge rate determined by 3 off 16in loadings arms, each rated at 5000M3/hr is 15,000M3/hr.

- Effective LNG cargo capacity of 138,000M3 LNGC is ~128,000M3 due to storage of LNG for fuel and maintenance of cold tanks

- Equivalent 128,000 M3 LNG volume's weight of SW Ballast volume required to be pumped into the LNGC Ballast Tanks per load = 0.4382 X 128,000M3 = 56090M3 SW

- LNG Volume received aboard FSRU per load= 128,000M3 LNG

- Equivalent LNG volume's weight of SW Ballast volume required to be removed from FSRU's Ballast Tanks = 0.4382 X 128,000M3 = 56090M3 SW per load

- Based on discharging 128,000M3 of LNG @ 15,000M3/hr rate, LNGC discharge period is ~8.5 hours. The actual discharge period will extend beyond this time due to the requirement to "ramp-up" the pumping rate at commencement and to slow down the pumping rate near the completion to facilitate safe "topping-up" of the LNG tanks.

- Rate of FSRU SW Ballast to be discharged due to LNG loaded from LNGC = 56090M3 ÷ 8.5 = 6600 M3/hr (**C**). Whilst the actual discharge rate will vary due to the LNG pumping factors noted above, plus operational practicalities the figure quoted provides a realistic estimation of the maximum flow rate to use in velocity determinations.

- LNG Volume removed from FSRU because of LNG that is Regasified to NG and sent to shore via pipeline from FSRU @ 800MMscfd rate = ~ 35,000M3 LNG per day

- Equivalent removed LNG volume's weight of SW Ballast volume required to be pumped into FSRU's Ballast Tanks (due to Regasification only) = 0.4382 X 35,000M3 = 15360M3 SW per day or 640 M3/hr (**D**). It should be noted that this is an average rate. Due to operational practicalities it is likely the ballast intake rate will be higher for two or three periods during each day, and be zero at other times.

- Volume of Ballast SW required to be discharged from FSRU during loading of a 138,000M3 LNGC is **C – D** = 5960 M3 /hr. As noted above **D** is an average rate, however, it is a reasonable basis for determining the maximum FSRU discharge rate.

- At all times except during LNGC loading into the FSRU, the SW Ballast is being added to the FSRU at rate **D**, 640M3/hr. Whilst this is an average rate, based on the factors noted above, it is a realistic figure to provide a velocity determination at the low end of the flow range.

4.2.3 LNGC Cargo Discharge Frequency

- LNGC cargo discharges to the FSRU are currently planned to occur on average 2.5 times per week, or 130 times per annum. This figure is based on the long term average gas delivery rate of 800MMscfd.

5 BALLASTING SYSTEM DESIGN

5.1 Ballasting Operations Process

LNGCs are required to undertake nearly continuous ballasting operations during LNG cargo discharge and loading operations. This requirement is due to the necessity of maintaining safe operational parameters for the vessel’s trim, list, stability, safe structural stresses & bending moments, and to maintain a reasonably constant relative freeboard between the LNGC and the LNG terminal’s dock (or, in this case, the FSRU) within the LNG cargo loading arms range of motion. The loading arms are designed to cater for a maximum elevation variation in the order of 1.0M. As the Cabrillo Port terminal is a FSRU, which is also a floating structure similar to an LNGC, it will also be required to undertake similar ballasting operations for the same reasons as an LNGC. For the Cabrillo Port terminal it is planned each LNGC discharge will be accomplished within a 24hour turn around window. The planned frequency of LNGC discharges to the FSRU is 2.5 times per week on average.

Whilst the maximum rate of loading LNG to the FSRU may be limited by a number factors including the LNGC’s cargo pumping rate capacity and the FSRU pipeline and valve sizes, for the purposes of calculating a maximum loading rate the limiting factor is the number and capacity of the loading arms. The proposed design is based on four installed arms, each with a capacity of 5000M3/hr, however, one arm is used for vapour return (Gaseous NG) to the LNGC. Thus the maximum LNG loading rate is 15000M3/hr, irrespective of other components in the loading system.

The LNG cargo tanks are separate and totally segregated from the water ballast tanks of both LNGCs and the FSRU. The water ballast tanks are used only for the purpose of containing seawater used as ballast, and the LNG cargo tanks are used only for the purpose of containing the LNG cargo.

Concurrent with the LNG cargo being discharged from a LNGC, the vessel will have to pump a volume of seawater into its ballast tanks similar to the weight of the volume of LNG cargo being pumped out of its cargo tanks. Simultaneously, the FSRU will need to discharge a volume of seawater ballast from its ballast tanks similar to the weight of the volume of LNG cargo it is receiving in its cargo tanks.

At all times, even during periods when the LNGC is alongside discharging LNG to the FSRU, the FSRU will be continuously vaporizing required volumes of LNG transferred from its cargo tanks to the vaporization equipment. The vaporization (also known as the regasification process) is accomplished using onboard submerged combustion LNG vaporizers (SCVs). The resultant gaseous natural gas (NG) is transported ashore via a subsea pipeline tied into a shoreside NG pipeline grid. Concurrent with the weight of LNG removed from the FSRU's cargo tanks for regasification and transport ashore, a volume of seawater must be pumped into the FSRU's ballast tanks equal in weight to the volume of LNG removed from the FSRU during this process.

A LNGC (or FSRU) loads/discharges seawater to/from its ballast tanks via a system of dedicated pumps, pipelines, and valves, which together comprise the ballast system. This piping system commences at through-hull opening fittings called sea chests which are connected via pipelines and valves to ballast pumps. Both the ballast sea chests and the ballast pumps are located low in the machinery spaces, near the bottom of the vessel, with the pumps relatively close to the sea chests. There will typically be one or two ballast sea chests on each side of the vessel and at least two dedicated main ballast pumps to serve an LNGC's ballast system.

The ballast pumps and sea chests are cross-connected with each other via a system of pipelines and valves providing operational flexibility and critical system redundancy, as well as for the purpose of controlling the flow direction of the ballast water.
The ballast discharge is typically achieved by the same system of pumps, pipelines and valves used for ballast intake. Discharge points will be provided on both sides of the vessel. For the purposes of velocity determinations the same pipe diameter and sea chest opening dimensions are used.

For the FSRU the proposed pump configuration is three installed (including one standby) ballast water pumps, each of nominally 3000M3/hr capacity and two sea chests. Thus the total maximum ballast pumping capacity is in excess of 6000M3/hr. This configuration is a preliminary arrangement and is subject to changes when detailed design is undertaken. Further factors to be taken into account during the detailed design include pipe friction losses and erosion rates, pump characteristics, screen filter sizes and sea chest arrangements.

This system also allows gravitation ballasting to take place under some circumstances, which bypasses use of the ballast pumps for water inflow into the ballast tanks until it reaches an equilibrium height within the tanks equal to the waterline external to the vessel. Conversely, deballasting the water from the ballast tanks can also be accomplished by the reverse gravitation flow method, similarly bypassing the ballast pumps until water level equilibrium is achieved. After equilibrium is achieved in either mode, the ballast pumps must be used for further filling or emptying of the ballast tanks.

In any case, this gravitation method is only used as a secondary ballasting/deballasting method when fill or emptying flow rates don't have to be maintained at normal full flow rates, such as when the LNG cargo transfer rate is temporarily reduced for whatever reason and the ballast tank water levels are within a range where gravitation of ballast can be acceptably accomplished.

The schematic diagram in Appendix A shows the basic configuration of the FSRU ballast system including sea chests, pumps and tanks together with their interconnecting pipes and valves.

Figures 1 & 2 show the proposed stern hull arrangement of the FSRU including preliminary locations for the BW system sea chests.

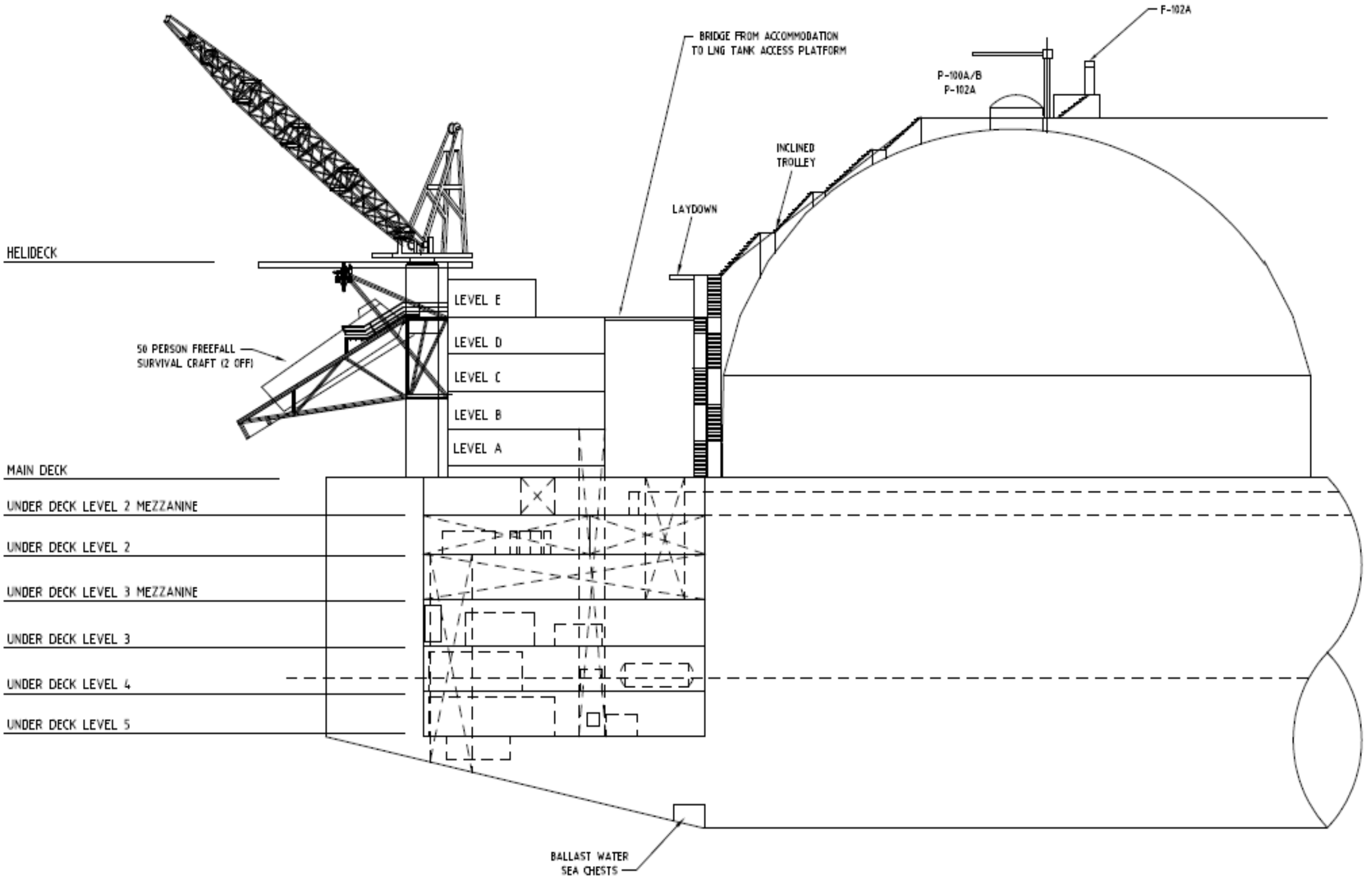

FIGURE 1 : STERN STARBOARD ELEVATION

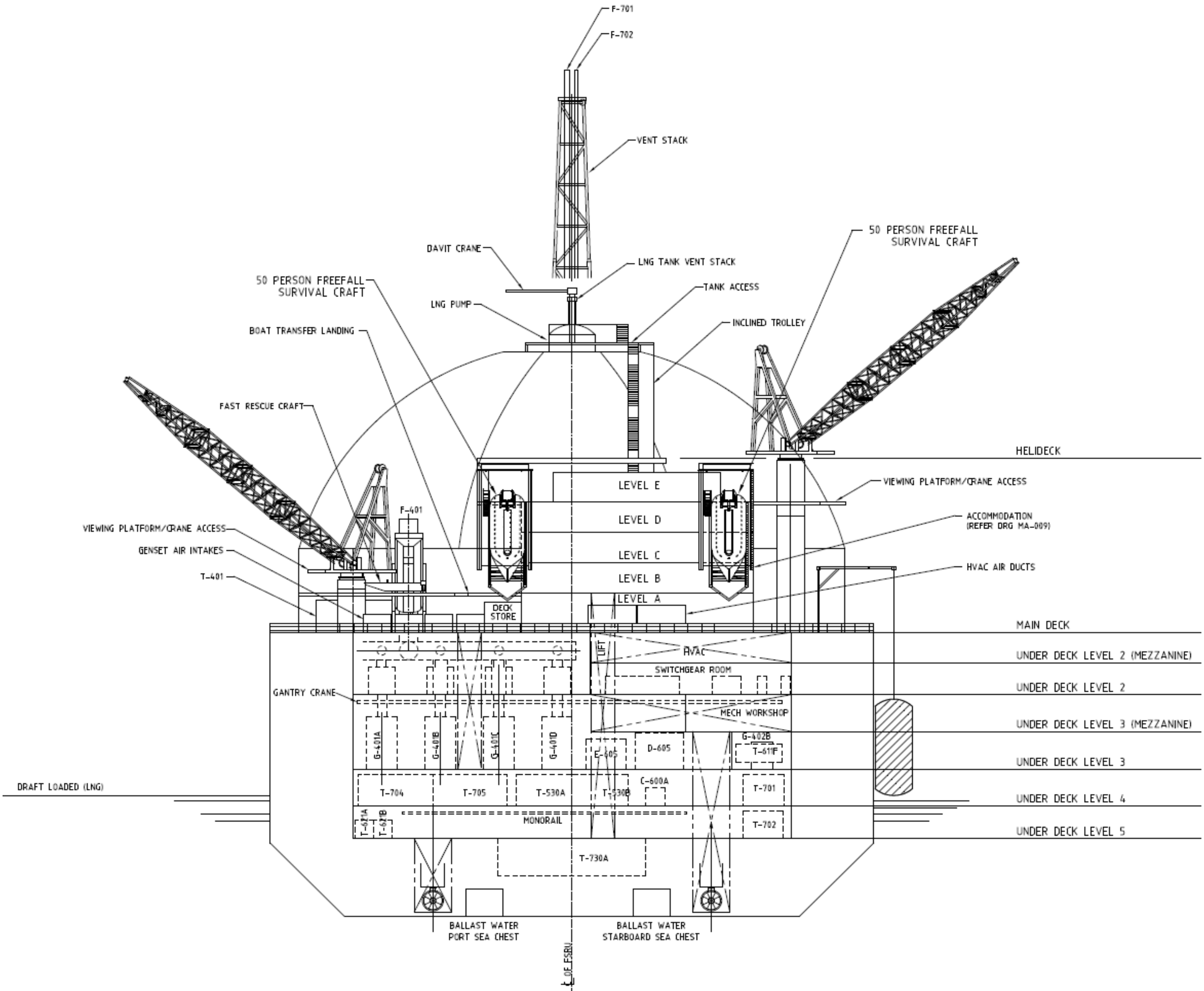

FIGURE 2 : STERN ELEVATION

5.2 Sea Chest Design

5.2.1 LNGC Sea Chest Design

For a LNGC the operational conditions which impact on locations for the sea chests will include trading in ports of variable available draft, sailing in a wide range of sea states, with a range of LNG tank levels from full to empty. The typical LNGC of the type which may discharge LNG at Cabrillo Port may have suction uptakes (in the form of sea chests) located at two different levels in the hull. These sea chests will typically be located on both sides of the vessel, providing short pipe runs to ballast pumps located on port and starboard sides of the vessel. The upper sea chests being utilised when the LNGC is in shallow water and the quality of SW at the suction uptakes could potentially be adversely affected by intake of sediment or a variety of marine growth. These alternative locations will be typically about 4M to 6M vertically apart.
The locations of the sea chests for the LNGCs will be also be based on a range of other factors determined by the vessel's design and builder. These factors include:

- The requirement to minimise skin friction on the vessel's hull
- Generation of laminar flow of water over the hull form
- Structural constraints- they must be located such that they do not jeopardise the vessel's hull integrity and strength. With a sea chest opening area typically being over 1.0M in diameter there is significant impact on the hull steelwork.
- Maintenance access- the sea chest is typically located such that the internal pipework and valving is accessible from within the vessel's machinery space
- Acceptable pump suction intake performance even when the vessel is in motion
- Clear of turbulent water found near a propeller as this would reduce pump suction performance

The size of the sea chest opening is normally based on providing an open area of at least twice the intake pipe area. For a typical LNGC this intake pipe is around 1.1M in diameter.
These constraints generally place major restrictions on the flexibility of a LNGC builder to place sea chests in other than a narrow range of locations within the hull.

5.2.2 FSRU Sea Chest Design

For the FSRU the requirement to facilitate good suction uptake performance in a range of water depths is not required. The FSRU is permanently moored in a water depth of more than 2600ft consequently the potential problems associated with BW intake from near the seabed are not relevant to the design. There are however, other considerations relevant to the FSRU sea chest locations, including:

- That the FSRU, unlike a LNGC does not visit shipyards for routine maintenance and inspection. Consequently the sea chests must be designed for extended periods between external inspection and maintenance.
- The FSRU does not travel through the water thus removing one element of "self-cleaning" provided by turbulence in sea chests on the LNGCs.
- The requirement to be clear of turbulent water found near a thruster as this would reduce pump suction performance

The FSRU detailed hull design is not finalised, however, the current proposal is to provide two BW sea chests, one to port side of hull centerline, and one to the starboard side. Refer to figures 1 & 2. It is anticipated the sea chest opening will be at least 1.0M2 in size.
During the course of detailed design development it is possible the FSRU designer or builder may choose to vary the number, location or size of the sea chests to align with a well proven arrangement for a similar sized LNGC.

5.3 Sea Chest Screen Design

5.3.1 LNGC Screens

A search of applicable international and USA marine codes, rules and regulations has failed to identify any specific technical requirements for ballast system sea chest screen design. For this equipment there are no known or known imminent industry or US regulations or officially recommended guidelines applicable to LNGC (or FSRU) vessels.
As noted previously the designs of the LNGC and FSRU ballast systems and sea chests, including screen numbers and sizes have not yet been finalised, however, they will be in full compliance with all applicable industry, international and US regulations and official guidelines existing at the time of construction.
The details described herein are based on common practice in LNGC and FPSO design. It should, however, be understood that there will exist large variations in the exact details of sea chest and screen design simply because of the wide variety of trading conditions, owner requirements and shipbuilding practices
An LNGC BW sea chest will typically be fitted with an external grill (or coarse filter) consisting of a grating with clearance spacings of ~ 25mm. This filter is designed to prevent ingress of large foreign matter or objects into the suction pipes and blocking or damaging the pumps and valves within the LNGC. It also helps prevent foreign matter from accumulating in the ballast tanks.
On the inboard (or vessel) side of each sea chest an isolation (or uptake) valve is fitted to facilitate isolation of the vessel's piping and filter systems. Downstream of this valve is a secondary fine filter or strainer, typically fitted with a single screen sized with ~6mm diameter holes. This strainer is accessible for cleaning by use of the isolation valve. This screen prevents the intake of marine growth or organisms, which if allowed to penetrate the ballast pumping system would lead to mechanical damage and fouling. The minimum size of the screen clearance size is limited by the requirement to avoid starvation of the ballast water pumps of water when operating at maximum flow.
The sizing and location of these the sea chests and screens are based on many years of trading tanker shipbuilding practice.

5.3.2 FSRU Screens

The detailed design for the FSRU has not been completed, however, it is envisaged that there is no basis for significant differences to the sea chest screen arrangements to those outlined for the LNGC. If at a later date specific requirements for sea chest screen arrangements are established and justified and do not adversely effect other essential performance attributes outlined in this report, then it may be possible to modify the FSRU design to suit.

5.4 Feasibility of Ocean Floor Intake

The feasibility of installing the FSRU BW pump uptake on the ocean floor has been investigated, however, is deemed totally impractical and unrealistic from both engineering and operational aspects. The following paragraphs explains the reasons for this assessment.

A subsurface intake from the ocean floor or near to it will lead to ingress of large volumes of sand and other particulates into the ballast water supply, requiring high quality filtration of the seawater onboard the FSRU prior to distribution. Intake of sand or similar particulate matter into the ballast water pumps would rapidly cause severe damage. To prevent blockage of the intake system large volumes of screenings/filtrate would need to be removed from the filter screens on a regular basis.

The suction of water from near the ocean floor will require a large diameter pipe to ensure the ballast pumps will not cavitate and therefore cease functioning. Suction from below the mud line will require an even larger pipe as the entrained sediments will lead to a heavier water column as well as having to compensate for the 'filtration' effect of the mud on the seawater. Suction from near to or particularly below the mud line will generate severe local damage to the seabed in the vicinity of the suction pipeline.
Apart from the hydraulic issues associated with lifting the required volume water over 800M the physical arrangements of the suction pipe are problematic.
There are three potential methods for piping ballast water onto the FSRU using a seabed based suction system - a suction pipe directly down from the aft end of the facility, or via a seawater swivel (technology basically similar to the equipment used for exporting gas from the FSRU to the shore) or using submerged pumps located on or near the ocean floor.

The 'direct suction' pipe will not be feasible as the facility rotates (or weathervanes) in response to changes in wind and current direction. The FSRU is connected to a mooring system which is connected to the ocean floor using anchor chains. As the FSRU weathervanes around its mooring, the suction pipe would be likely to become tangled in the mooring anchor chains.

A large diameter swivel could be theoretically employed, allowing the FSRU to weathervane while the ballast suction line, like the gas pipelines, remains stationary. The ballast water pumps have the capability to “lift” or suck water no more than 10M above their intake level. Because the swivel on the FSRU is around more than 22M above this level, a vapour lock would occur in the pump suction line. Therefore, such a system would not be operable.

The third potential method is the use of submerged pumps that would take suction at the sea bottom and pump the water onto the FSRU via a large diameter swivel. Such a system would rely on transmission of significant electrical power over the 800M water depth and would require electrical and piping swivels. Consequently this method would be extremely expensive and complicated for such a critical safety related system. The failure of the ballast water pumping system would have the potential to shutdown production and threaten the vessels ability to remain within safe operating parameters.

From our evaluations it is not practical to locate the ballast water intakes either in the ocean floor substrate or in that vicinity.

5.5 Summary of LNGC and FSRU Ballast System Volumes, Flow Rates, Velocities

The following tables summarise the information described in the text and provide additional information with respect to expected seawater flow velocities in the sea chests and the ballast water system 0.6M diameter pipe. It should be noted that for any given flow rate the velocity through pipe or pumps will not be exactly constant across any given plane, however, the flows indicated in the tables are based on accepted industry practice for determination of flow velocities.

Table 1 details the maximum flow velocities for the case where a 210,000M3 LNGC is discharging to the FSRU. The velocities detailed are based on the full flow for a single pump through a single sea chest and a single pipe branch to the pump.

Table 2 details the maximum flow velocities for the case where a 138,000M3 LNGC is discharging to the FSRU. The velocities detailed are based on the full flow for a single pump through a single sea chest and a single pipe branch to the pump.

Table 3 details the minimum flow velocities for the normal operation case when the FSRU is discharging regasified gas to the shore. A period of one day is selected based on the long term average NG delivery rate of 800MMscfd.

Refer to schematic no.0501-009-02 in Appendix A for the proposed FSRU ballast system schematic arrangement.

Table 1

Activity: 210,000M3 LNGC Cargo Discharge to FSRU + FSRU Regasification / NG Export					
Ballast Activity	**Period**	**BW Volume Intake/Discharge**	**Flow Rate (per pump)**	**Maximum Velocity**	
				At Sea Chest (Area)	In Pipe (Diam,Ø.)
LNGC Ballast **Intake**	13 hours	85,449M3	Max- 3287 M3/hour	(1.9M2) **0.48M/s**	(1.1MØ) **0.96M/s**
FSRU Ballast **Discharge**	13 hours	77142M3	Max-2967 M3/hour	(1.0M2) **0.82M/s**	(0.6MØ) **3.05M/s**

Table 2

Activity: 138,000M3 LNGC Cargo Discharge to FSRU + FSRU Regasification / NG Export					
Ballast Activity	**Period**	**BW Volume Intake/Discharge**	**Flow Rate (per pump)**	**Maximum Velocity**	
				At Sea Chest (Area)	In Pipe (Diam.Ø)
LNGC Ballast **Intake**	8.5 hours	56090M3	Max- 3299 M3/hour	(1.9M2) **0.48M/s**	(1.1MØ) **0.96M/s**
FSRU Ballast **Discharge**	8.5 hours	50660M3	Max-2980 M3/hour	(1.0M2) **0.83M/s**	(0.6MØ) **3.07M/s**

Table 3

Activity: FSRU Vaporisation (LNG Regasifying / NG export only)					
Ballast Activity	**Period**	**Volume / Day (Due to Regas. Only)**	**Flow Rate (per pump)**	**Minimum Velocity**	
		Based on 800MMscfd		At Sea Chest (Area)	In Pipe (Diam.Ø)
FSRU Ballast **Intake**	Continuous	15,360M3	640M3/hour	(1.0M2) **0.18 M/s**	(0.6MØ) **0.66M/s**

Appendix A. – Schematic
Drawing No. 0501-009-02- Ballast System Schematic